Homework 5

1. *Bipolar junction transistors*
2. Draw an npn transistor showing the n and p regions. What are the three currents in a transistor, and how are they related? (10)

## Base-Biased transistor circuit

1. Design a base-biased circuit in Multisim using a 2N3904. (You decide reasonably your circuit’s $V\_{BB} V\_{CC} R\_{B} and R\_{C}$). Why is this circuit likely to fail in mass production if a precise value of current gain is needed? Insert your schematics below. (10)
2. Calculate your designed circuit’s base current $I\_{B}$. Compare your value with your simulation. Show your simulation with the voltage meters values below. (5)
3. What is the collector-emitter voltage $V\_{CE} $? Show your work. Compare your value with your simulation. Show your simulation with the voltage meters values below. (5)
4. Emitter follower transistor circuit – Current source
5. Design a LED driver circuit with emitter bias (Emitter follower). Your driver should be able to serve as at least 5mA and no more than 20mA of current to a LED light of your choice. Build a voltage divider to supply the voltage for the base so your driver only needs one DC voltage supply. Draw the schematics with Multisim and insert the simulation below. Your simulation should be running, and the LED is lit up. Show (the math) how this driver can provide 20mA of current consistently regardless what type of LED you have. (10)
6. What is your LED driver’s collector-emitter voltage $V\_{CE} $? Is the transistor working in its active region? Show your work. Compare your value with your simulation. Show your simulation with the voltage meters values below. (5)
7. Can your driver drive five LEDs in series with them being equally bright? How many LEDs can your driver handle? Calculate the current flowing through your series of LEDs (Hint, it’s $I\_{C}$). Does the current change every time you add an LED? Draw the schematics with Multisim with (a number of LEDs) LEDs lit with equal brightness. (5)
8. *Voltage-Divider Bias circuit*

Design a VDB circuit that

* + $R\_{1}∥R\_{2}<0.01β\_{dc}R\_{E}$ (You can set beta=100 in Multisim)
	+ The current flowing through the voltage divider $I\_{VD}<I\_{C}$, preferably $I\_{VD}<0.1I\_{C}$
	+ Emitter voltage $V\_{E}≈0.1V\_{CC}$
	+ About half of $V\_{CC}$ appear across the collector-emitter terminals: $V\_{CE}≈0.5V\_{CC}$
	+ You can decide the value of $V\_{CC}$.
1. Show all the calculation below that how you picked the proper resistors to satisfy the design requirements above. Is your transistor working in the active region? Insert your simulation schematics below. (10)
2. Calculate $I\_{B}, I\_{C} and I\_{E}$. Compare your calculation with simulation data. Display the three Volt/Ampere meters values in your simulation below. (10)